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RESEARCH MEMORANDUM

for the

Bureau of Aeronautics, Department of the Navy

WIND-TUNNEL INVESTIGATION AT LOW SPEED OF THE STATIC

LONGITUDINAL AND LATERAL STABILITY CHARACTERISTICS

OF A 1/9-SCALE POWERED MODEL OF THE CONVAIR

XFY-1 VERTICALLY RISING AIRPLANE

TED NO. NACA DE 373

By M. J. Queijo, W. D. Wolhart, and H. S. Fletcher

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Langley Field, Va.

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WIND-TUNNEL INVESTIGATION AT LOW SPEED OF THE STATIC
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SUMMARY

An experimental investigation has been made in the Langley stability tunnel at low speed to determine the static longitudinal and lateral stability characteristics of a 1/9-scale powered model of the Convair XFY-1 vertically rising airplane. Effects of thrust coefficient were investigated for the complete model and for certain components of the model. Effects of control deflections and of propeller-blade angle were investigated briefly for the complete model. Most of the tests were made through an angle-of-attack range from about -4° to 29° , and the thrust-coefficient range was from 0 to 0.7.

In order to expedite distribution of these data to interested persons, no analysis of the data has been prepared for this report.

INTRODUCTION

Various investigations have shown that the dynamic stability characteristics of high-speed aircraft are critically dependent on certain mass and aerodynamic parameters, and, hence, reliable estimates of the dynamic stability of such aircraft can be made only if these parameters are determined accurately. The purpose of the present investigation was

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to determine the static aerodynamic parameters of a powered model of the Convair XFY-1 vertically rising airplane from a series of tests at low speed in the Langley stability tunnel. These tests were made at the request of the Bureau of Aeronautics, Department of the Navy, to aid in the development of the Convair XFY-1 airplane.

SYMBOLS AND COEFFICIENTS

The data presented herein are in the form of standard NACA coefficients of forces and moments which are referred to the system of stability axes (Fig. 1) with the origin at the projection of the 14-percent-wing mean aerodynamic chord on the plane of symmetry. This system of axes is defined as an orthogonal system having the origin at the assumed center of gravity with the Z-axis in the plane of symmetry and perpendicular to the relative wind, the X-axis in the plane of symmetry and perpendicular to the Z-axis, and the Y-axis perpendicular to the plane of symmetry. Positive directions of forces, moments, and displacements are shown in figure 1.

b	theoretical wing span, 2.86 ft
c	local wing chord, ft
$\bar{c}$	wing mean aerodynamic chord, $\bar{c} = \frac{2}{S} \int_0^{b/2} c^2 dy$, 1.73 ft
d	local propeller-blade chord, ft
h	maximum blade thickness at local chord
D	propeller diameter, ft
q	dynamic pressure, $\frac{1}{2}\rho V^2$, lb/sq ft
r	radial distance from propeller-hub center line, ft
R	propeller radius, 0.889 ft
S	area of theoretical wing, 4.27 sq ft
V	free-stream velocity, ft/sec
y	spanwise distance from plane of symmetry, ft
α	wing angle of attack, deg

β	sideslip angle, radians unless otherwise specified
$(\beta_0)_F$	front propeller-blade angle measured at 0.75R, deg
γ	angle of climb, deg
δ_e	elevator deflection, positive trailing edge up, deg — <i>opposite to normal</i>
δ_R	rudder deflection, positive trailing edge to right, deg
ψ	angle of yaw, deg
θ	local propeller-blade angle, deg <i>usually 23</i>
ϕ	angle of roll, deg
ρ	mass density of air, slugs/cu ft
L	lift, lb
X	longitudinal force, lb
Y	side force, lb
T	thrust, lb ($T = X_{\text{propellers on}} - X_{\text{propellers off}}$, for complete model at $\alpha = 0^\circ$)
M	pitching moment, ft-lb
N	yawing moment, ft-lb
l	rolling moment, ft-lb
C_L	lift coefficient, L/qS
C_X	longitudinal-force coefficient, X/qS
C_Y	side-force coefficient, Y/qS
T_c'	thrust coefficient, T/qS
C_m	pitching-moment coefficient, $M/qS\bar{c}$
C_n	yawing-moment coefficient, N/qSb
C_l	rolling-moment coefficient, l/qSb

$$C_{Y_\beta} = \partial C_Y / \partial \beta$$

$$C_{n_\beta} = \partial C_n / \partial \beta$$

$$C_{l_\beta} = \partial C_l / \partial \beta$$

Abbreviations:

W	wing
T _u	upper tail
T _L	lower tail
F	fuselage
P	propeller

Subscripts:

F	front
L	left
R	right

MODEL AND APPARATUS

The model used in this investigation was a 1/9-scale powered model of the Convair XFY-1 vertically rising airplane. Pertinent geometric characteristics of the model are given in figure 2. The wing consisted of a core made from 1/2-inch-thick duralumin, and was built up to the proper contour with laminated mahogany. The fuselage and fins were constructed of laminated mahogany. All control surfaces were made of solid duralumin. The wing and fins had modified NACA 63-009 airfoil contours parallel to the model thrust line.

The propeller blades (geometric characteristics given in fig. 3) were constructed of heat-treated duralumin, and were driven by a 50-horsepower water-cooled motor. The motor was equipped with a dual-rotation gear box. Power for the model motor was supplied by a 75-kilowatt motor-generator set which is part of the equipment of the

Langley stability tunnel. Propeller speeds were measured by means of a Strobocorr unit in conjunction with an alternator driven directly by the model motor.

A two-strut support system was used to attach the model to a 6-component balance system. Photographs of the model mounted on the struts are given as figure 4.

TESTS

All tests of this investigation were made at a dynamic pressure of 16 pounds per square foot, which corresponds to a Mach number of about 0.11 and a Reynolds number of 1.28×10^6 based on the wing mean aerodynamic chord of 1.73 feet. Most of the tests were made with the controls in a neutral position and with the front blades set at $(\beta_0)_F = 25^\circ$. A few tests were made to determine the effects of blade angle on the static derivatives. In all cases the rear blades were set at 1° less than the front blades. Effects of control deflections also were investigated briefly.

The static longitudinal and lateral stability parameters of three basic model configurations were investigated, and these configurations were

$$W + F + P$$

$$W + F + T_{11} + P$$

and

$$W + F + T_H + T_L + P$$

The characteristics of these configurations with propellers removed also were investigated.

The angle-of-attack range for all tests was from about -4° to 29° . Sideslip characteristics were determined from tests made at $\beta = \pm 5^\circ$. Some sideslip tests were made in which β was varied from -20° to 20° for certain angles of attack.

Power-on data were obtained for several thrust coefficients T_c' from 0 to 0.7. Data were obtained by holding propeller speed constant while varying α and β . The scope of this investigation can be clearly seen by a study of table I.

CORRECTIONS

Approximate corrections for jet-boundary effects were applied to the angle of attack and sideslip angle by the methods of reference 1. Blockage corrections were determined and applied by the methods of reference 2. Strut-tare corrections were applied to all the data, except that shown plotted against sideslip angle. Tare corrections were determined and found to be negligible in the sideslip range from -5° to 5° . Tare corrections were not determined outside this sideslip range.

PRESENTATION OF RESULTS

The results of the investigation are presented in figures 5 to 14. The data, model configuration, and figure on which the data are shown are indicated in table I for convenience in locating desired information. Moment data are referred to the system of stability axes with the origin at the projection of the 14-percent mean aerodynamic chord on the plane of symmetry.

In order to expedite distribution of these data to interested persons, no analysis of the data has been prepared; however, some spot checks with data from references 3 and 4 were made. In general, all the data are in fair agreement with regard to the effects of power and variation of aerodynamic parameters with lift coefficient. Some differences in actual values were noted, but there appear to be several reasons:

- (a) Differences in model configuration.
- (b) Differences in test procedure. (The present investigation was made holding constant propeller speed for constant thrust coefficient. In reference 3 the propeller speed was varied with angle of attack (or sideslip) for constant thrust runs.)
- (c) Blockage corrections were not applied to the data of reference 3.
- (d) Moment data of references 3 and 4 are given about $0.15\bar{c}$, whereas the data presented in this paper are about $0.14\bar{c}$.

CONCLUDING REMARKS

An experimental investigation has been made in the Langley stability tunnel at low speed to determine the static longitudinal and lateral stability characteristics of a 1/9-scale powered model of the Convair XFV-1 vertically rising airplane. Effects of thrust coefficient were

investigated for the complete model and for certain components of the model. Effects of control deflections and of propeller-blade angle were investigated briefly for the complete model. Most of the tests were made through an angle-of-attack range from about -4° to 29° , and the thrust-coefficient range was from 0 to 0.7.

In order to expedite distribution of these data to interested persons, no analysis of the data has been prepared for this report.

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1. Silverstein, Abe, and White, James A.: Wind-Tunnel Interference With Particular Reference to Off-Center Positions of the Wing and to the Downwash at the Tail. NACA Rep. 547, 1936.
2. Herriot, John G.: Blockage Corrections for Three-Dimensional-Flow Closed-Throat Wind Tunnels, With Consideration of the Effect of Compressibility. NACA Rep. 995, 1950. (Supersedes NACA RM A7B28.)
3. Pieper, C. W.: Low-Speed Wind Tunnel Tests of a .15 Scale Powered Model of the XFV-1 Airplane. Rep. No. CVAL 96, Consolidated Vultee Aircraft Corp., Jan. 18, 1952.
4. Wall, P. J.: A Preliminary Analysis of the First Series of High-Speed Wind Tunnel Tests of the Convair Model 5 Airplane. Rep. No. A-5-27, Consolidated Vultee Aircraft Corp., Mar. 3, 1952.

TABLE I

SUMMARY OF MODEL CONFIGURATIONS TESTED, TEST VARIABLES, AND DATA PRESENTED

Model condition	Data presented	Figure
$W + F + T_u + T_L + P,$ $(\beta_o)_F = 25^\circ, 35^\circ, \text{ and } 50^\circ$	T_c' against propeller speed	5
$W + F + T_u + T_L,$ $W + F + T_u + T_L + P, (\beta_o)_F = 25^\circ$	α, C_X, C_m against C_L for various thrust coefficients	6
$W + F + T_u + T_L,$ $W + F + T_u + T_L + P, (\beta_o)_F = 35^\circ$	α, C_X, C_m against C_L for various thrust coefficients	7
$W + F + T_u + T_L,$ $W + F + T_u + T_L + P, (\beta_o)_F = 50^\circ$	α, C_X, C_m against C_L for various thrust coefficients	8
$W + F,$ $W + F + P, (\beta_o)_F = 25^\circ$	$C_{Y\beta}, C_{l\beta}, C_{n\beta}$ against C_L for various thrust coefficients	9(a)
$W + F + T_u,$ $W + F + T_u + P, (\beta_o)_F = 25^\circ$	$C_{Y\beta}, C_{l\beta}, C_{n\beta}$ against C_L for various thrust coefficients	9(b)
$W + F + T_u + T_L,$ $W + F + T_u + T_L + P, (\beta_o)_F = 25^\circ$	$C_{Y\beta}, C_{l\beta}, C_{n\beta}$ against C_L for various thrust coefficients	9(c)
$W + F + T_u + T_L + P,$ $(\beta_o)_F = 25^\circ, T_c' = 0.4$	$C_{Y\beta}, C_{l\beta}, C_{n\beta}$ against α for various control deflections	10
$W + F,$ $W + F + P, (\beta_o)_F = 25^\circ, T_c' = 0.4$	C_Y, C_l, C_n against β for $\alpha = 2.1^\circ, 12.5^\circ, \text{ and } 20.7^\circ$	11
$W + F + T_u,$ $W + F + T_u + P, (\beta_o)_F = 25^\circ, T_c' = 0.4$	C_Y, C_l, C_n against β for $\alpha = 2.1^\circ, 12.5^\circ, \text{ and } 20.7^\circ$	12
$W + F + T_u + T_L,$ $W + F + T_u + T_L + P, (\beta_o)_F = 25^\circ, T_c' = 0.4$	C_Y, C_l, C_n against β for $\alpha = 2.1^\circ, 12.5^\circ, \text{ and } 20.7^\circ$	13
$W + F + T_u + T_L + P,$ $T_c' = 0, 0.2, \text{ and } 0.4$	$C_{Y\beta}, C_{l\beta}, C_{n\beta}$ against C_L for $(\beta_o)_F = 25^\circ, 35^\circ, \text{ and } 50^\circ$	14



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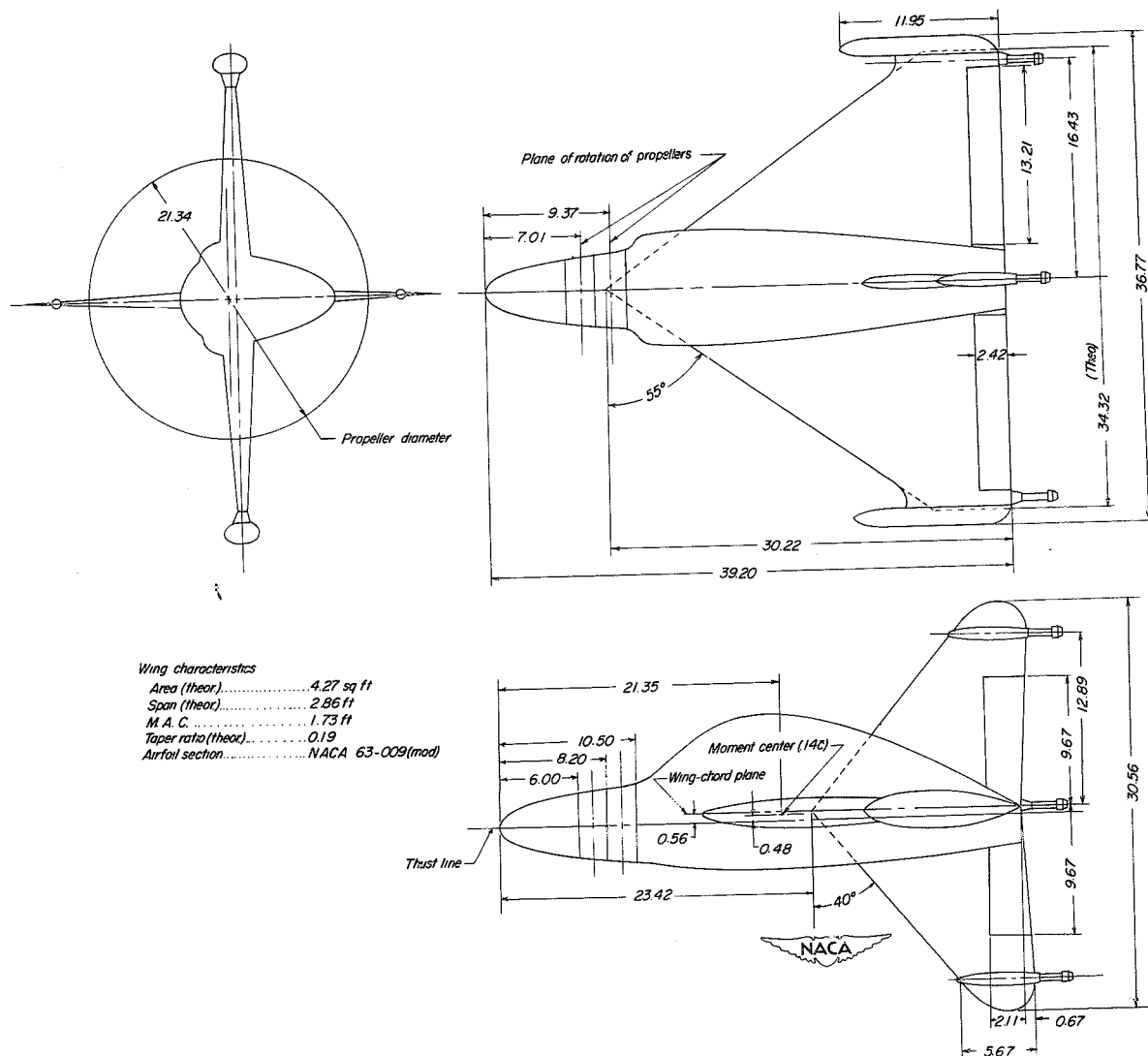


Figure 2.-- Geometric characteristics of model. All dimensions are in inches.

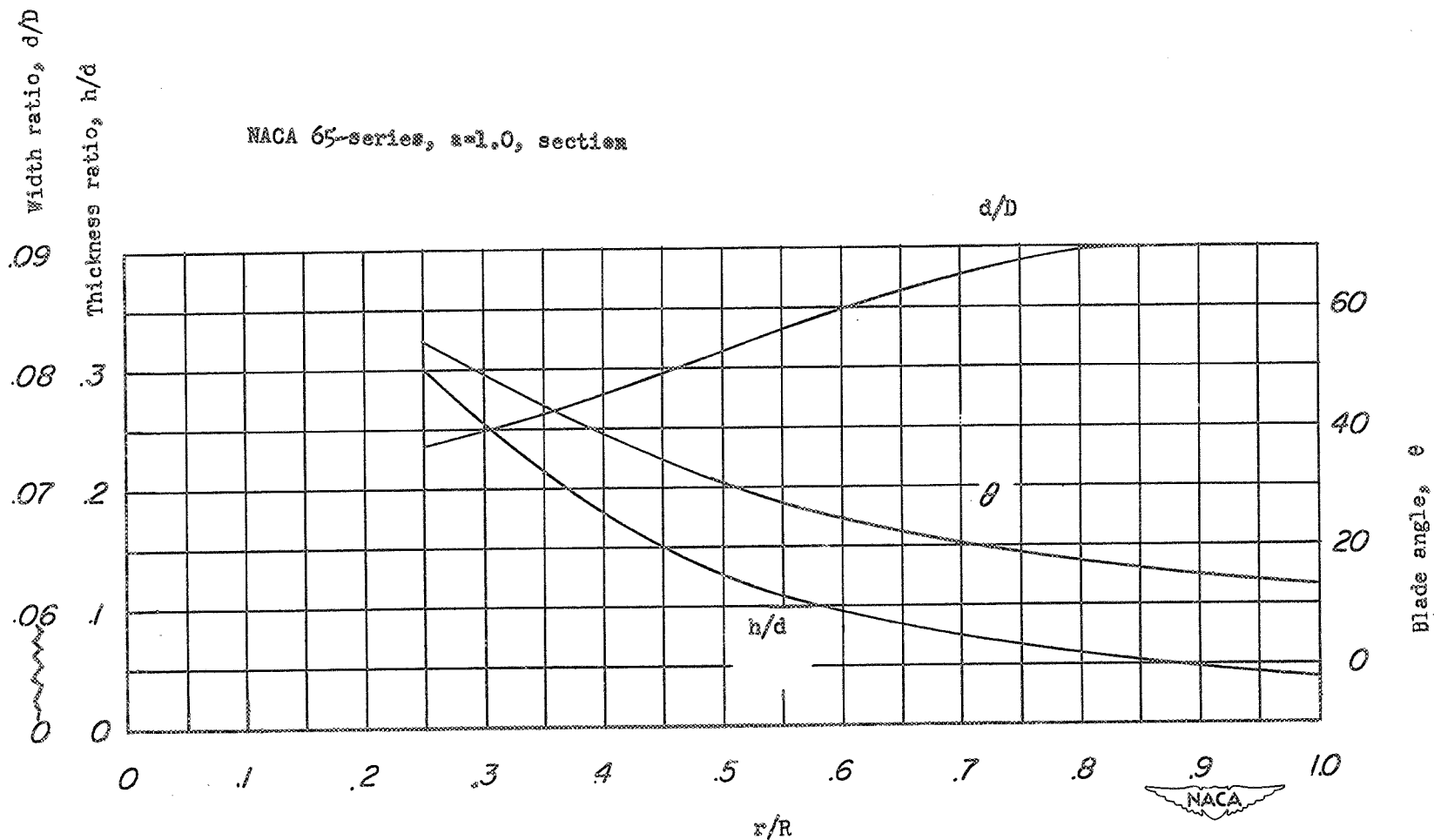
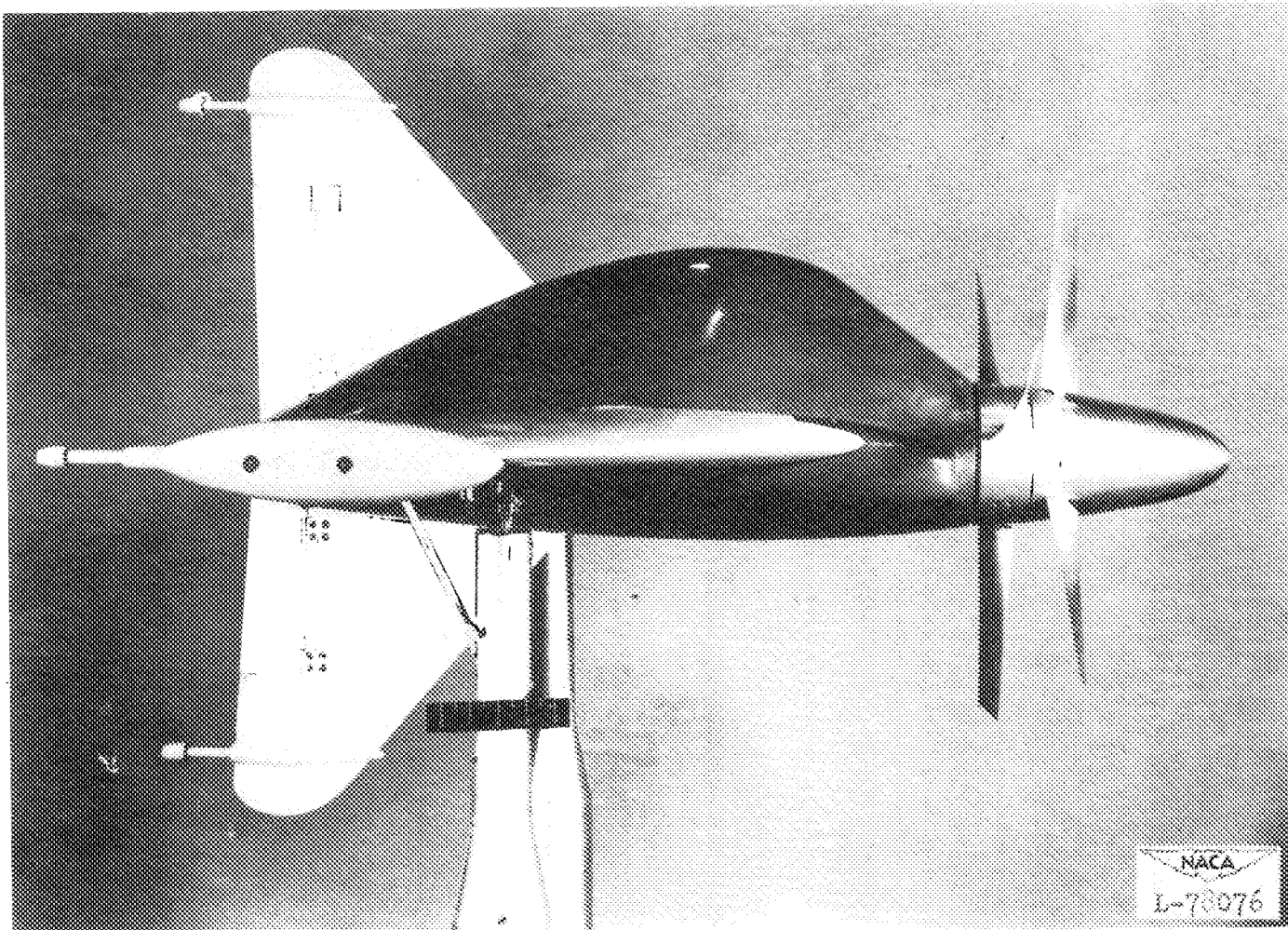


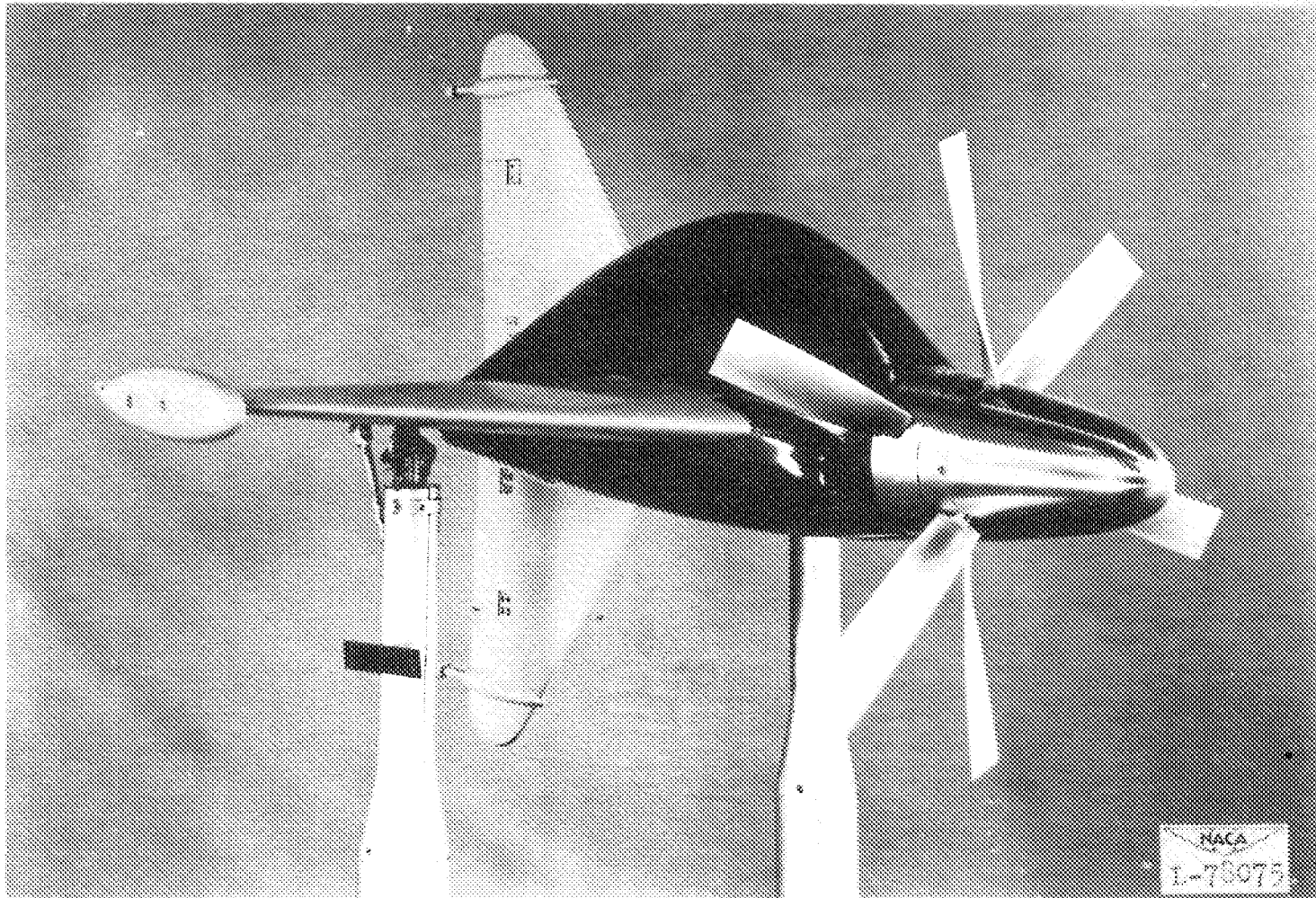
Figure 3.- Geometric characteristics of propeller blades used on a 1/9-scale model of the Convair XFY-1 vertically rising airplane.
 $R = 0.889$ feet.



(a) Side view.

Figure 4.- Photographs of model used in investigation.

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(b) Three-quarter front view.

Figure 4.- Concluded.

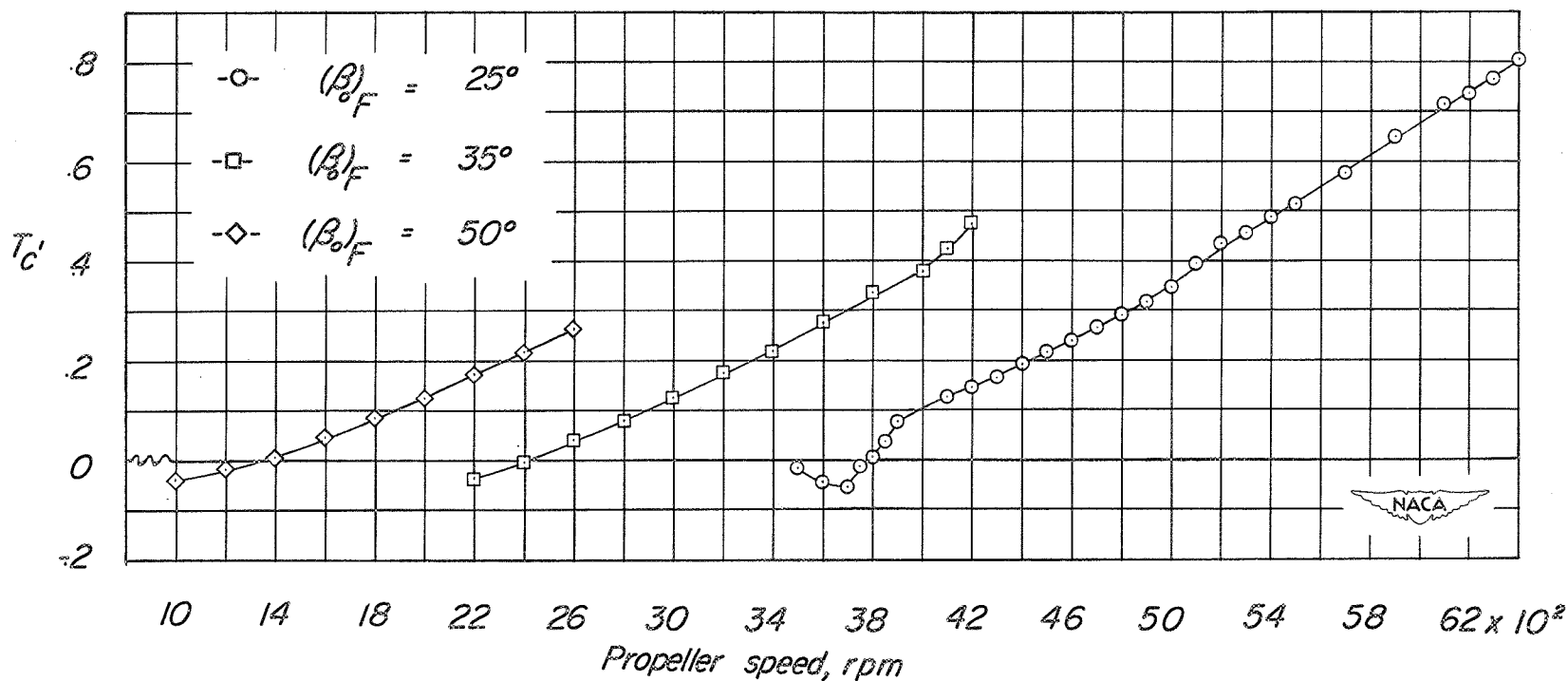


Figure 5.- Variation of thrust coefficient with propeller speed for various propeller-blade angles. $\alpha = 0^\circ$.

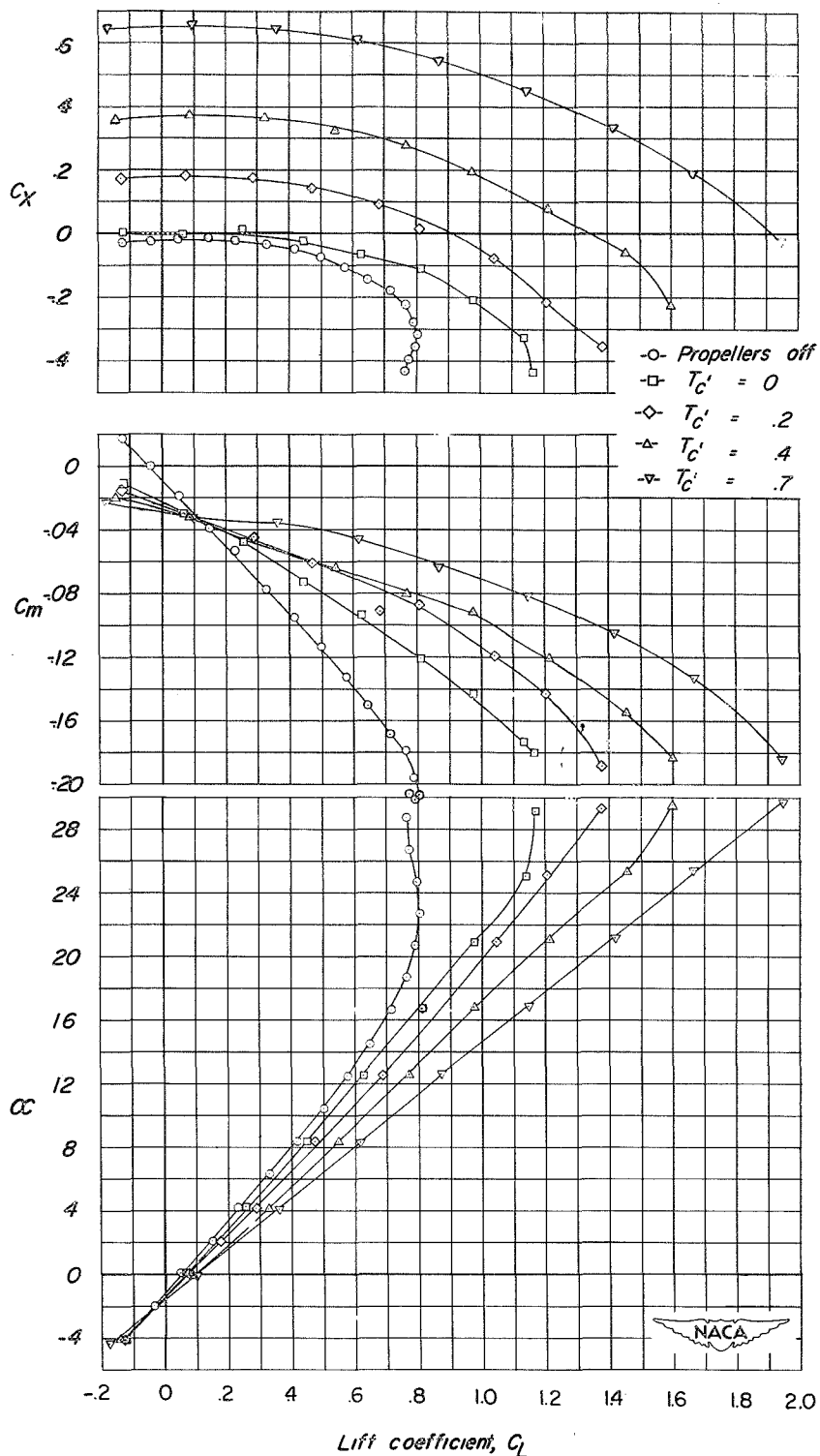


Figure 6.- Effect of thrust coefficient on the static longitudinal stability characteristics of a 1/9-scale powered model of the Convair XFY-1 vertically rising airplane. Complete model. $(\beta_0)_F = 25^\circ$.

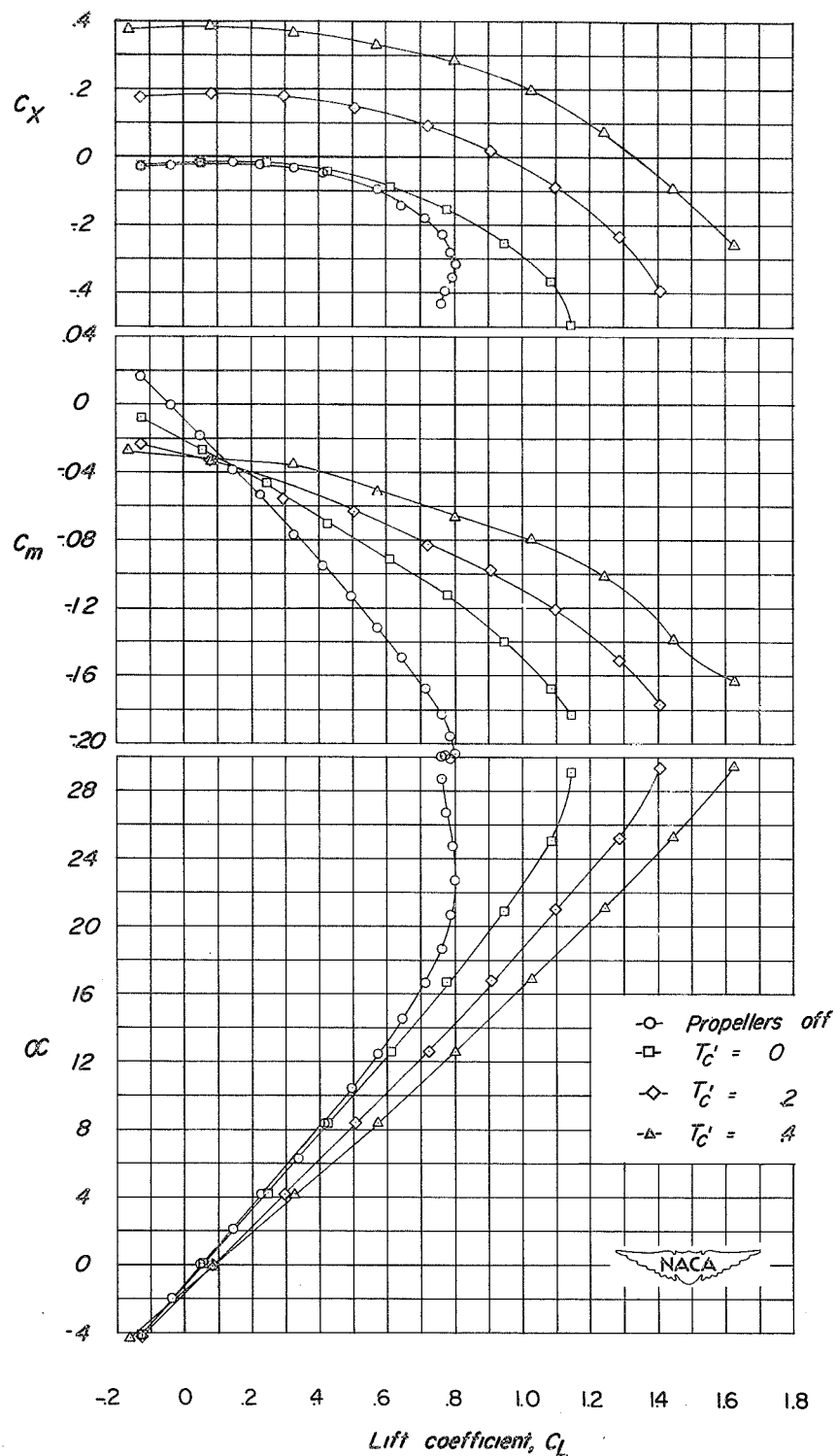


Figure 7.- Effect of thrust coefficient on the static longitudinal stability characteristics of a 1/9-scale powered model of the Convair XFY-1 vertically rising airplane. Complete model. $(\beta_0)_F = 35^\circ$.

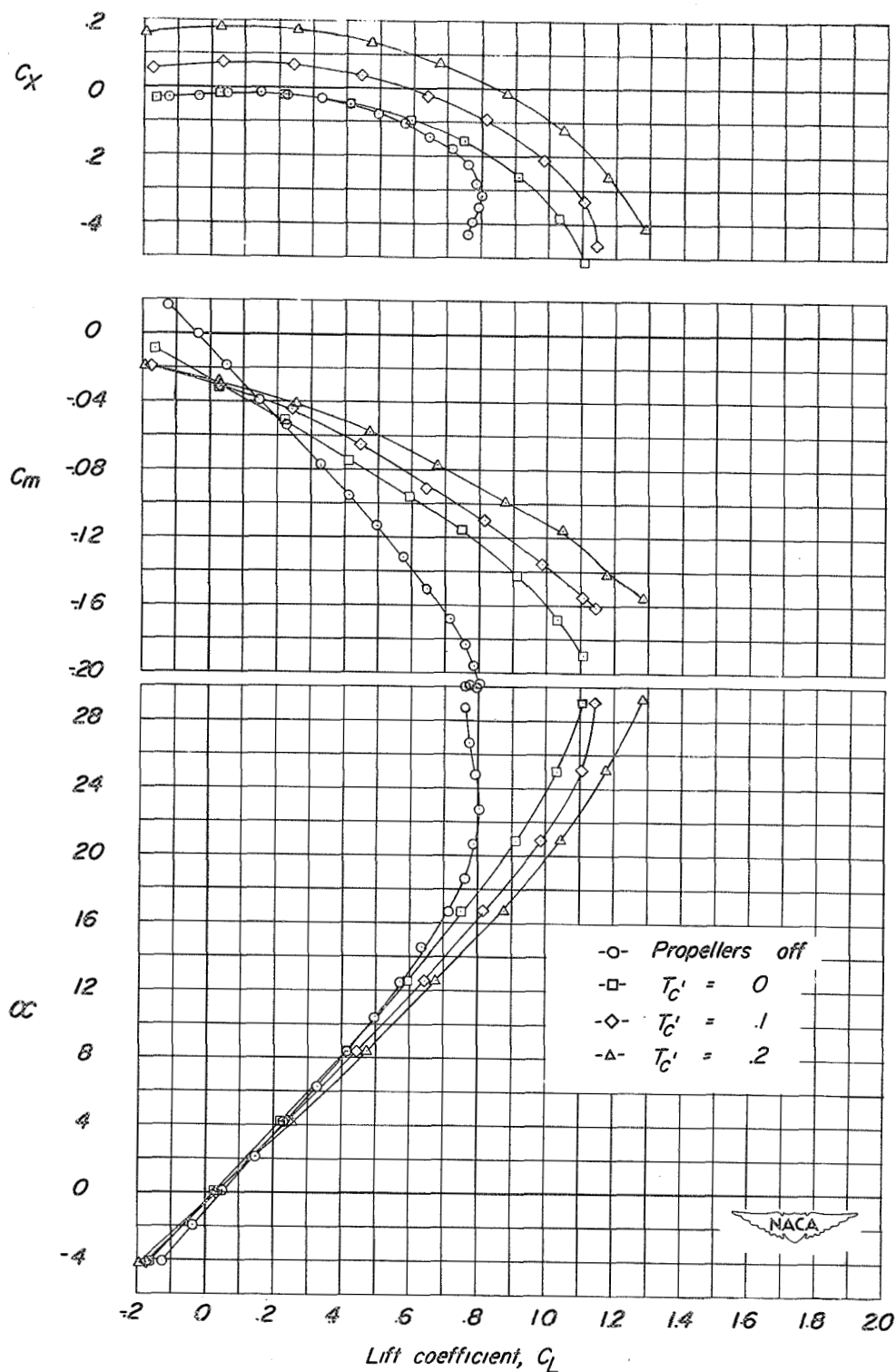
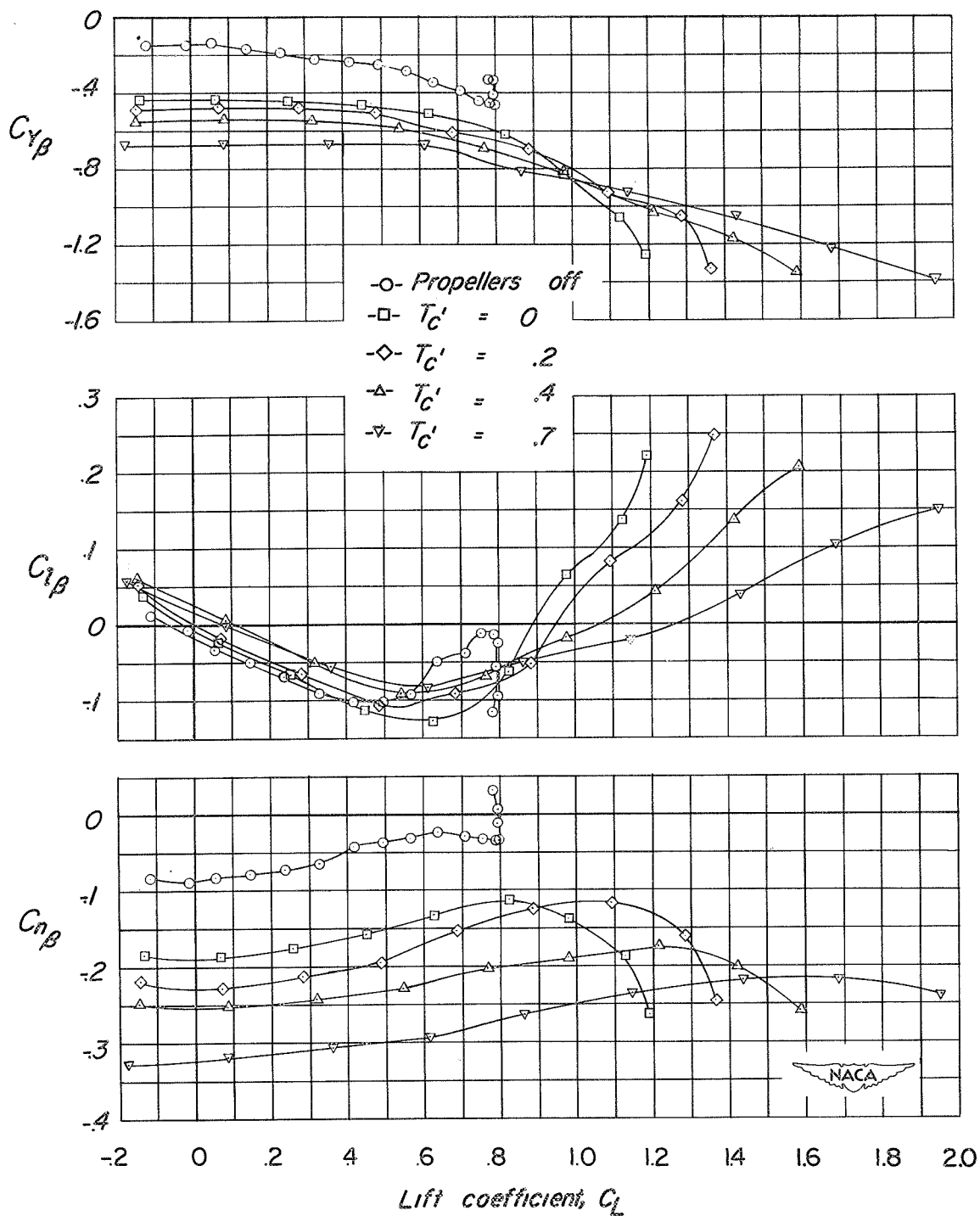
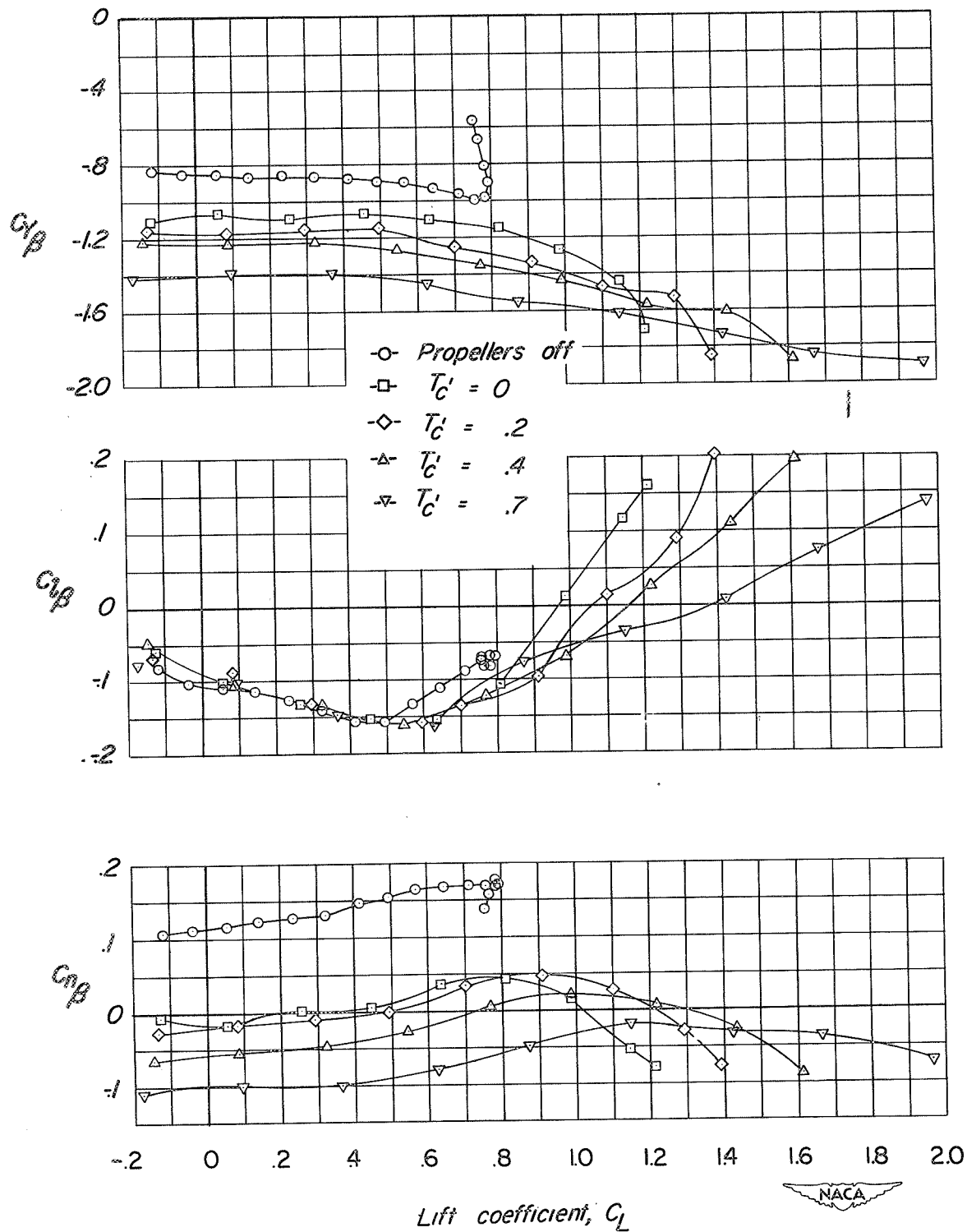


Figure 8.- Effect of thrust coefficient on the static longitudinal stability characteristics of a 1/9-scale powered model of the Convair XFY-1 vertically rising airplane. Complete model. $(\beta_0)_F = 50^\circ$.



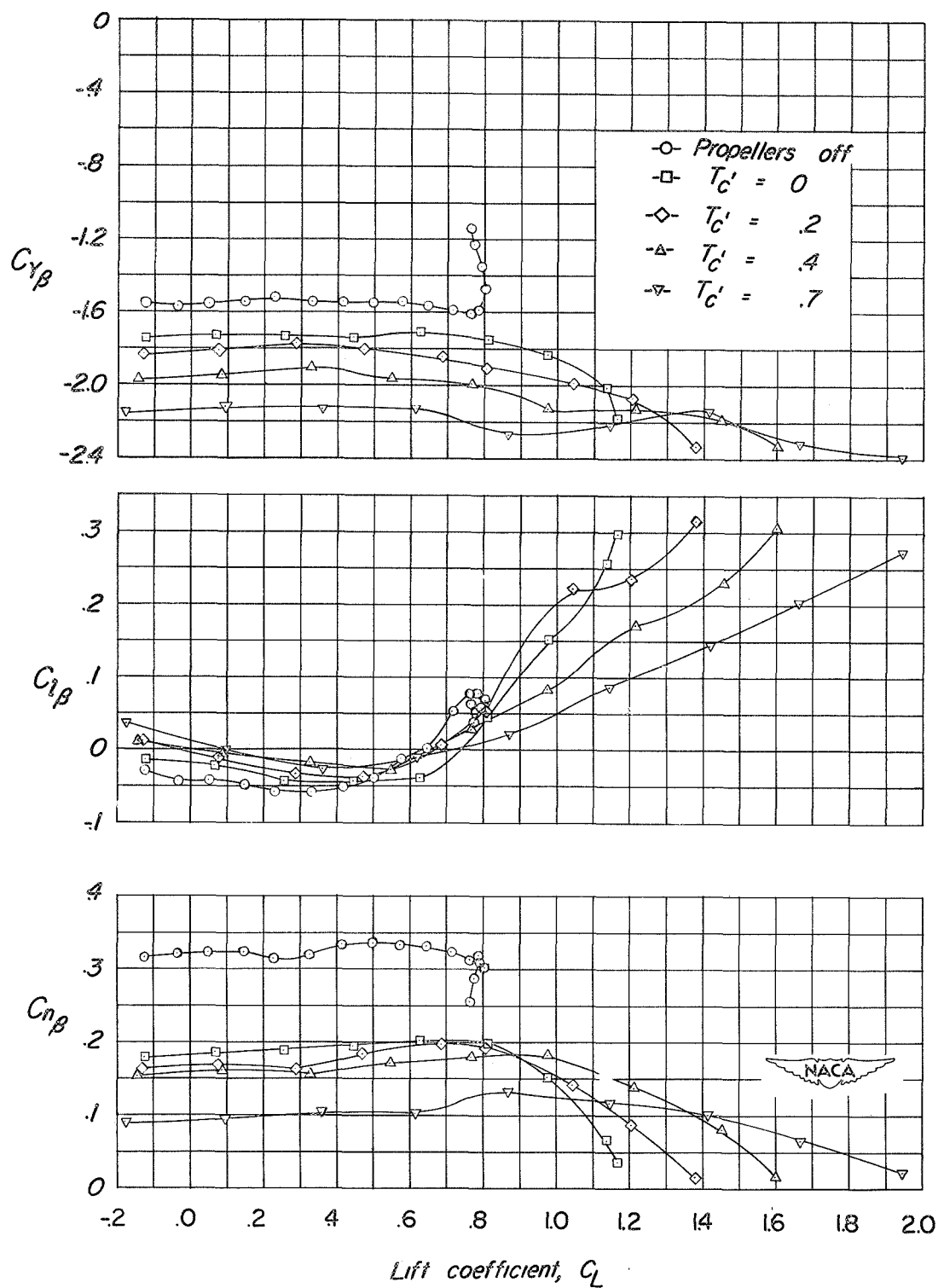
(a) Both fins off.

Figure 9.- Effect of thrust coefficient on the static lateral stability characteristics of various components of a 1/9-scale powered model of the Convair XFY-1 vertically rising airplane. $(\beta_o)_F = 25^\circ$.



(b) Lower fin off.

Figure 9.- Continued.



(c) Complete model.

Figure 9.- Concluded.

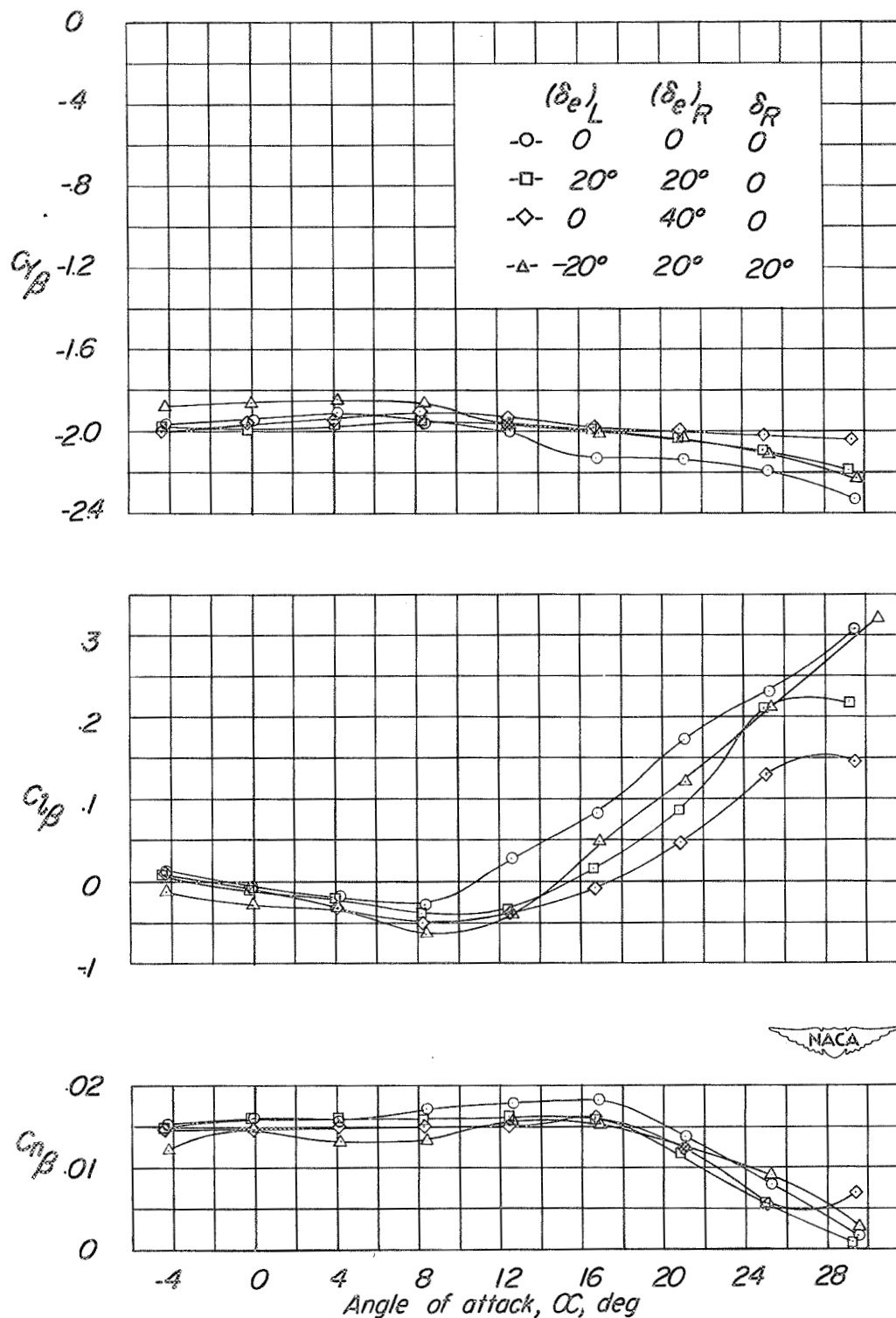
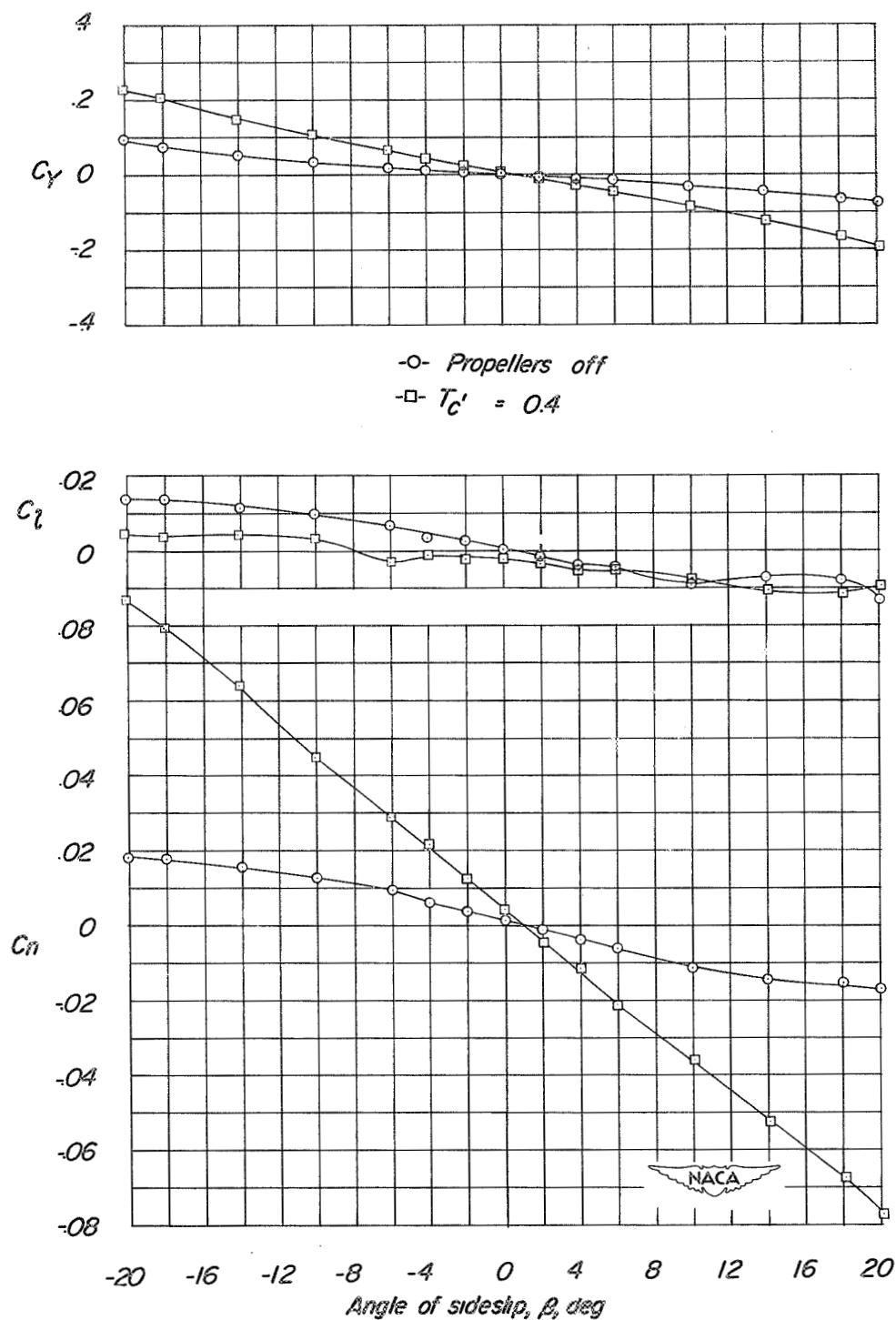
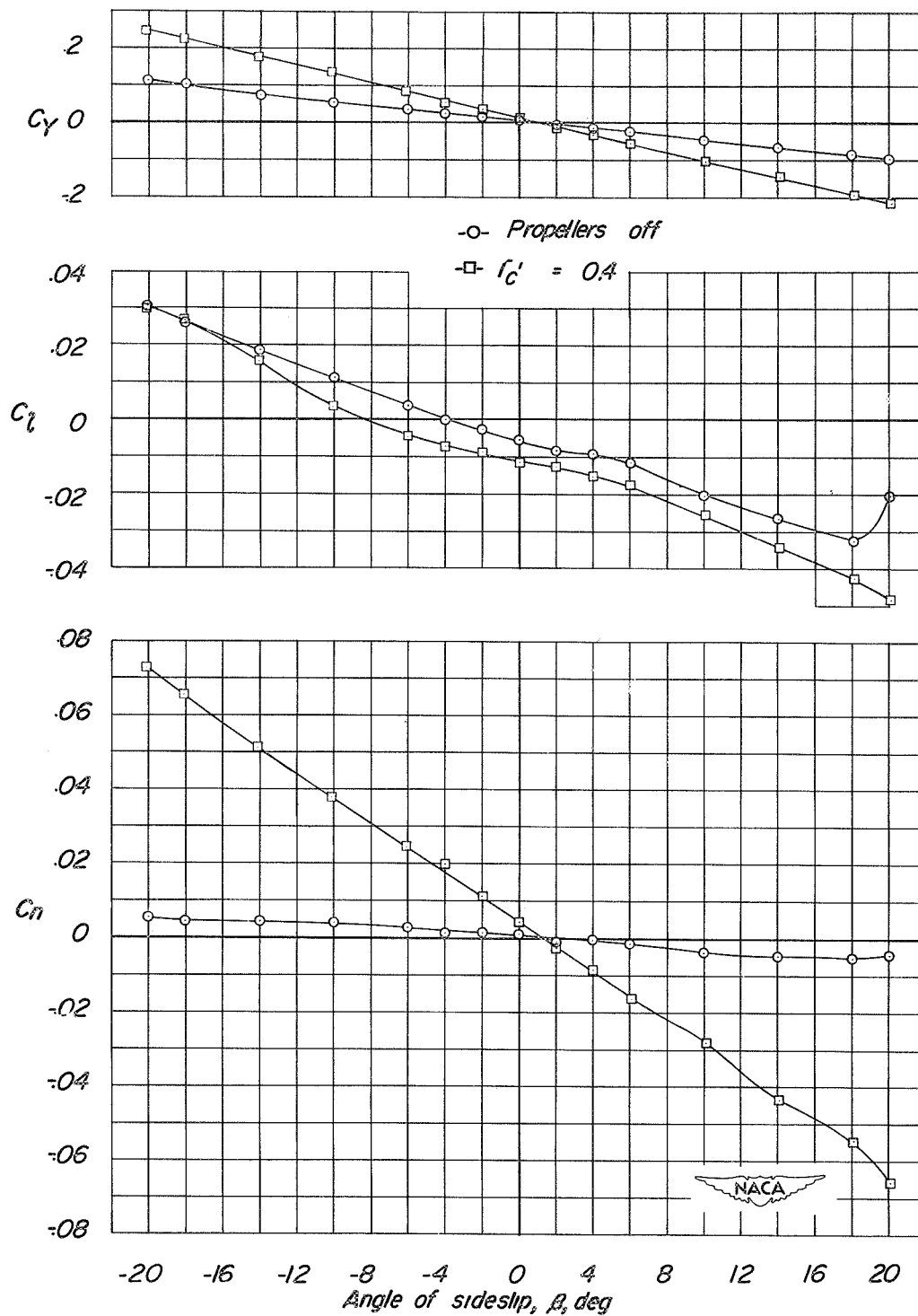


Figure 10.- Effect of various control deflections on the static lateral stability parameters of a 1/9-scale powered model of the Convair XFY-1 vertically rising airplane. $(\beta_0)_F = 25^\circ$; $T_c' = 0.4$.



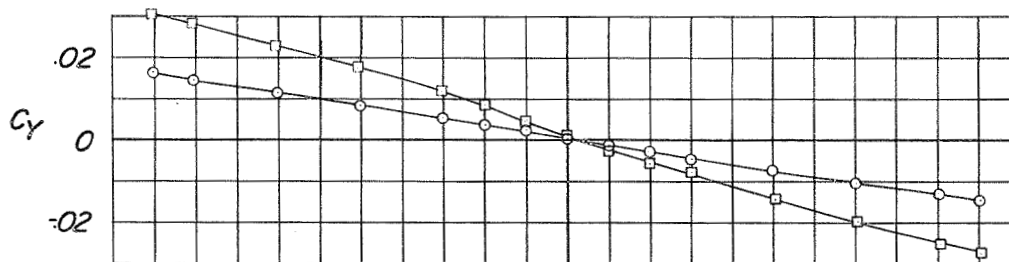
(a) Both fins off. $\alpha = 2.1^\circ$.

Figure 11.— Effect of power on the variation of C_Y , C_L , and C_N with sideslip angle for various angles of attack. Both fins off. $(\beta_0)_F = 25^\circ$.



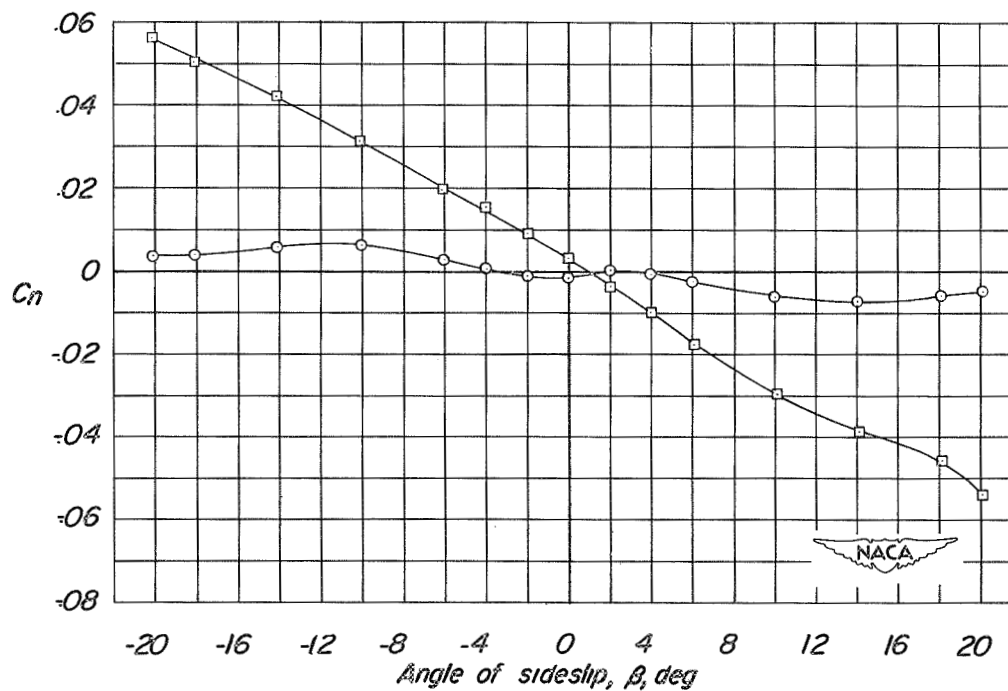
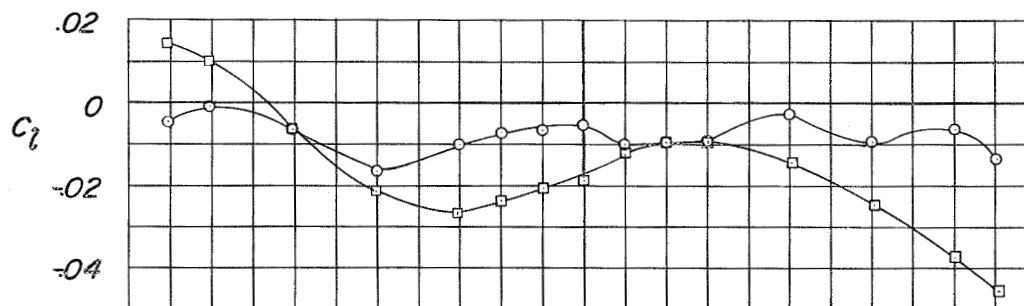
(b) Both fins off. $\alpha = 12.5$.

Figure 11.- Continued.



$\circ$ Propellers off

$\square$ $T_{c'} = 0.4$



(c) Both fins off. $\alpha = 20.7$.

Figure 11.- Concluded.

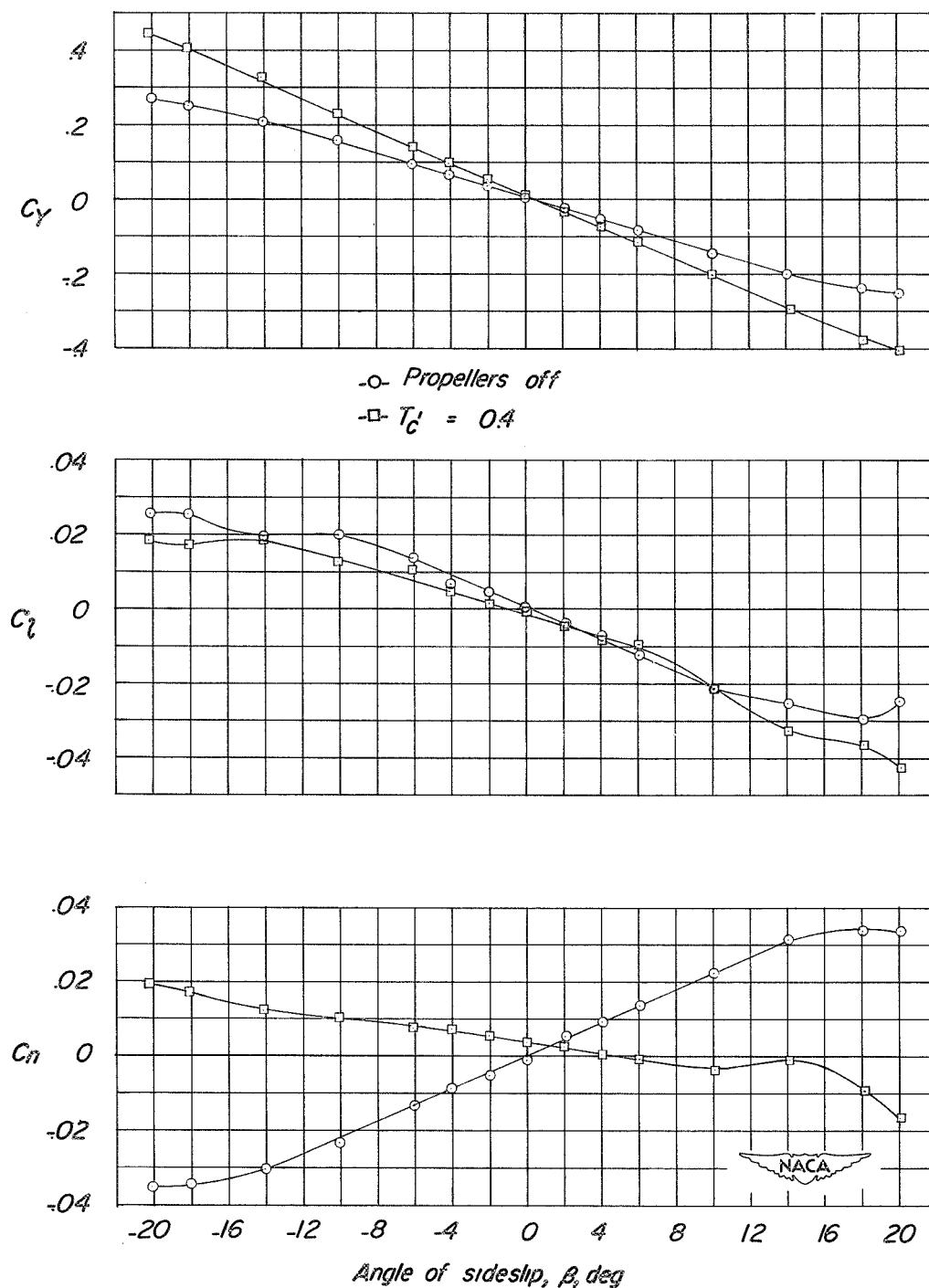
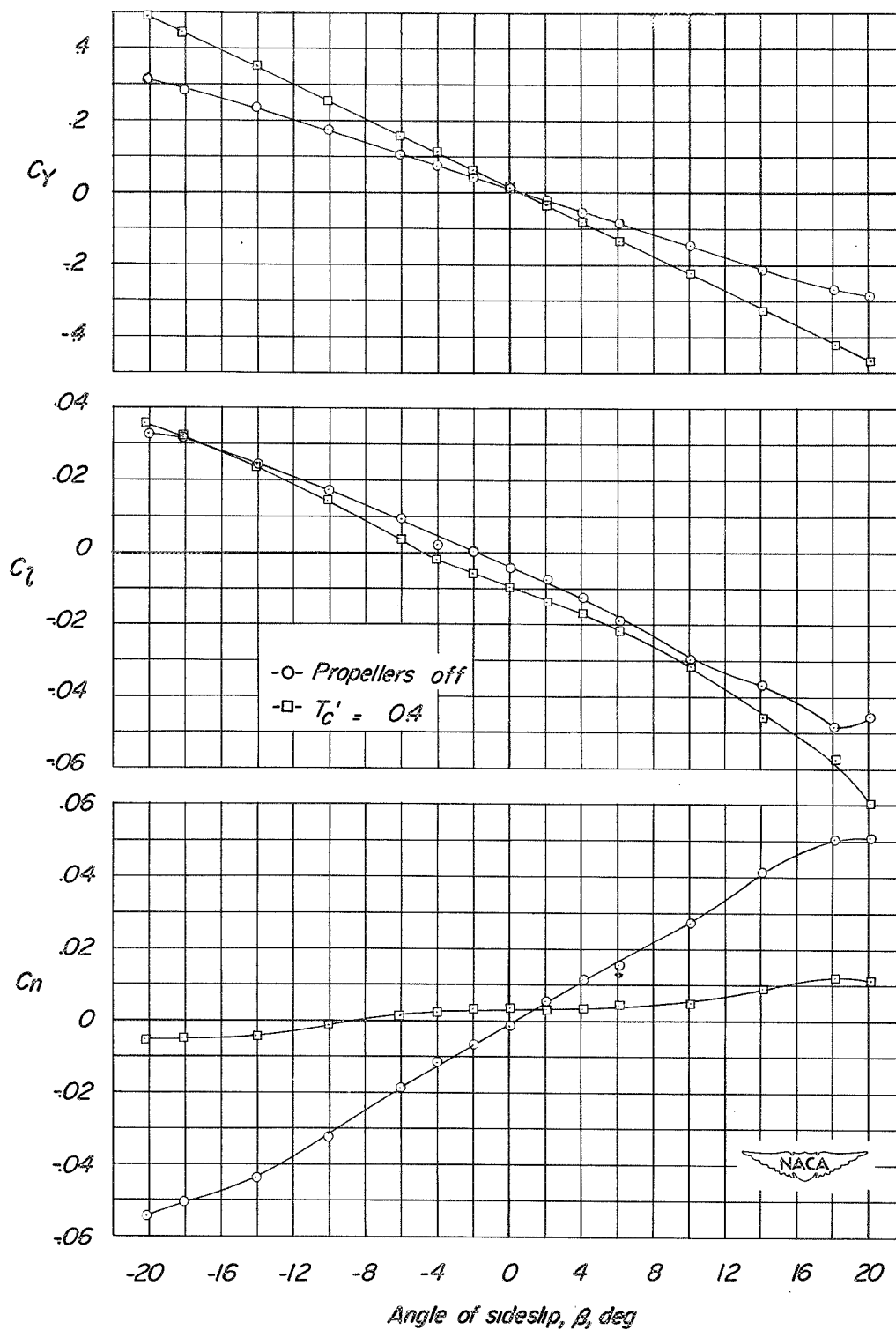
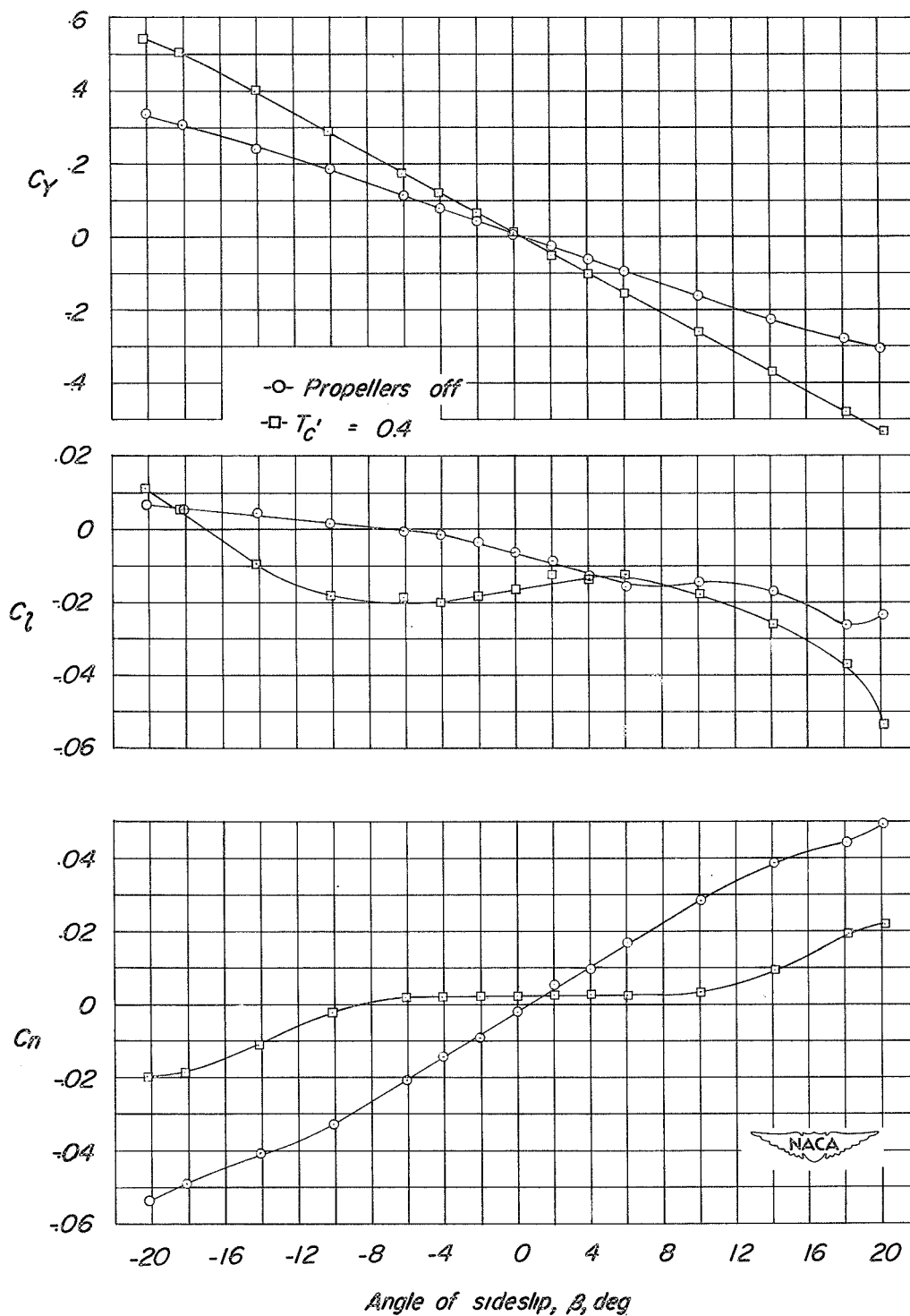
(a) Lower fin off. $\alpha = 2.1$.

Figure 12.-- Effect of power on the variation of C_Y , C_L , and C_N with sideslip angle for various angles of attack. Lower fin off. $(\beta_o)_F = 25^\circ$.



(b) Lower fin off. $\alpha = 12.5$.

Figure 12.- Continued.



(c) Lower fin off. $\alpha = 20.7^\circ$.

Figure 12.- Concluded.

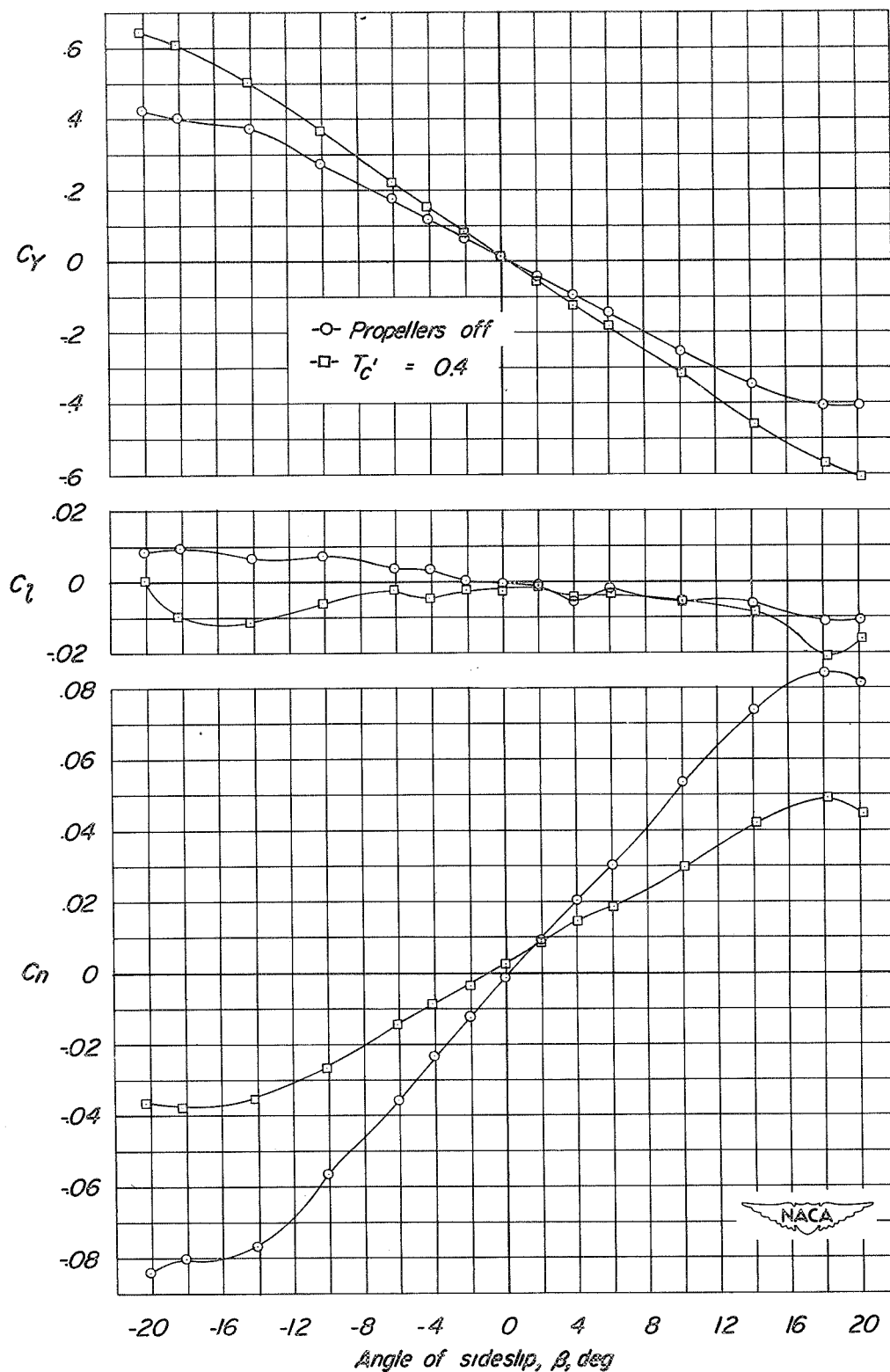
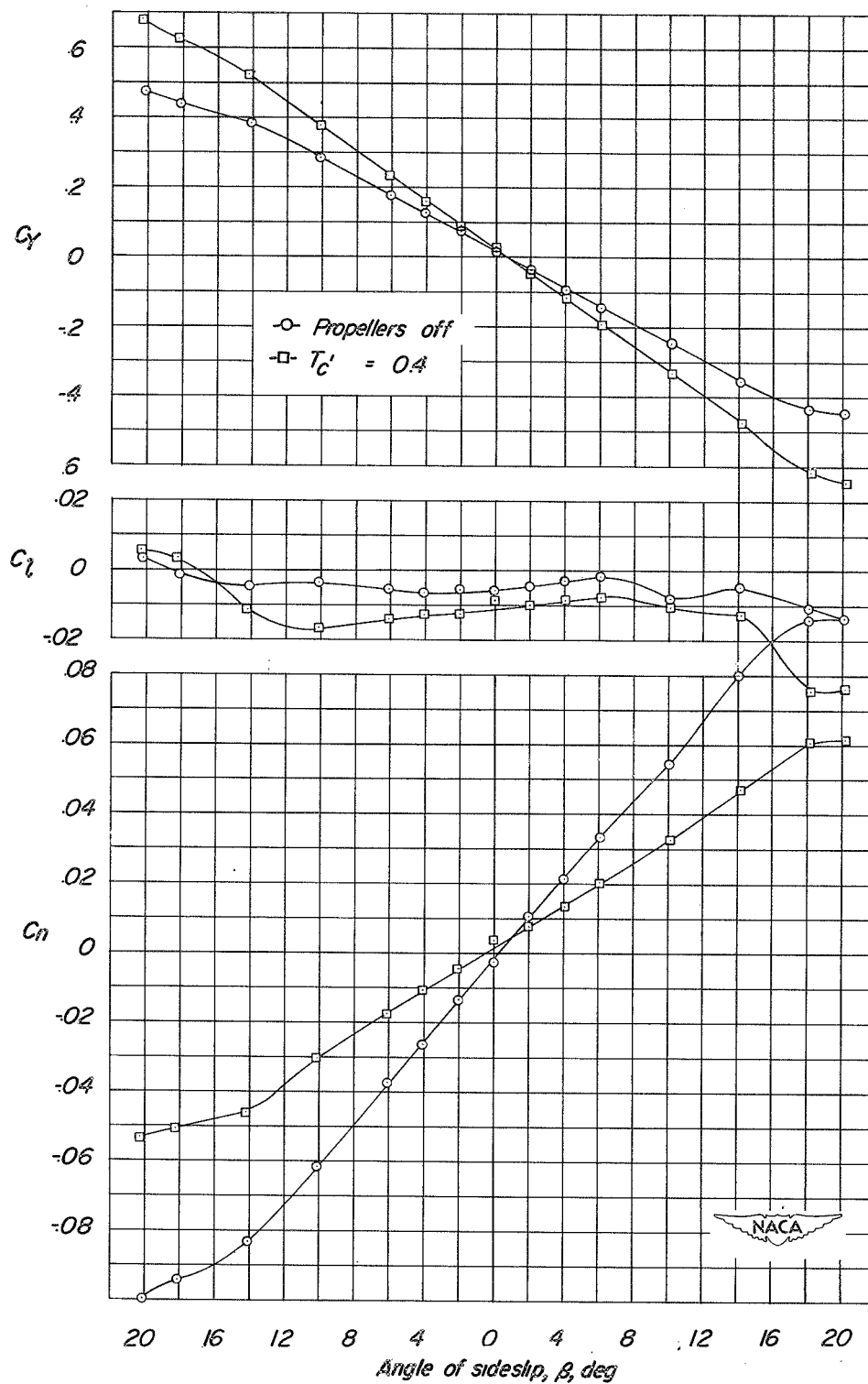
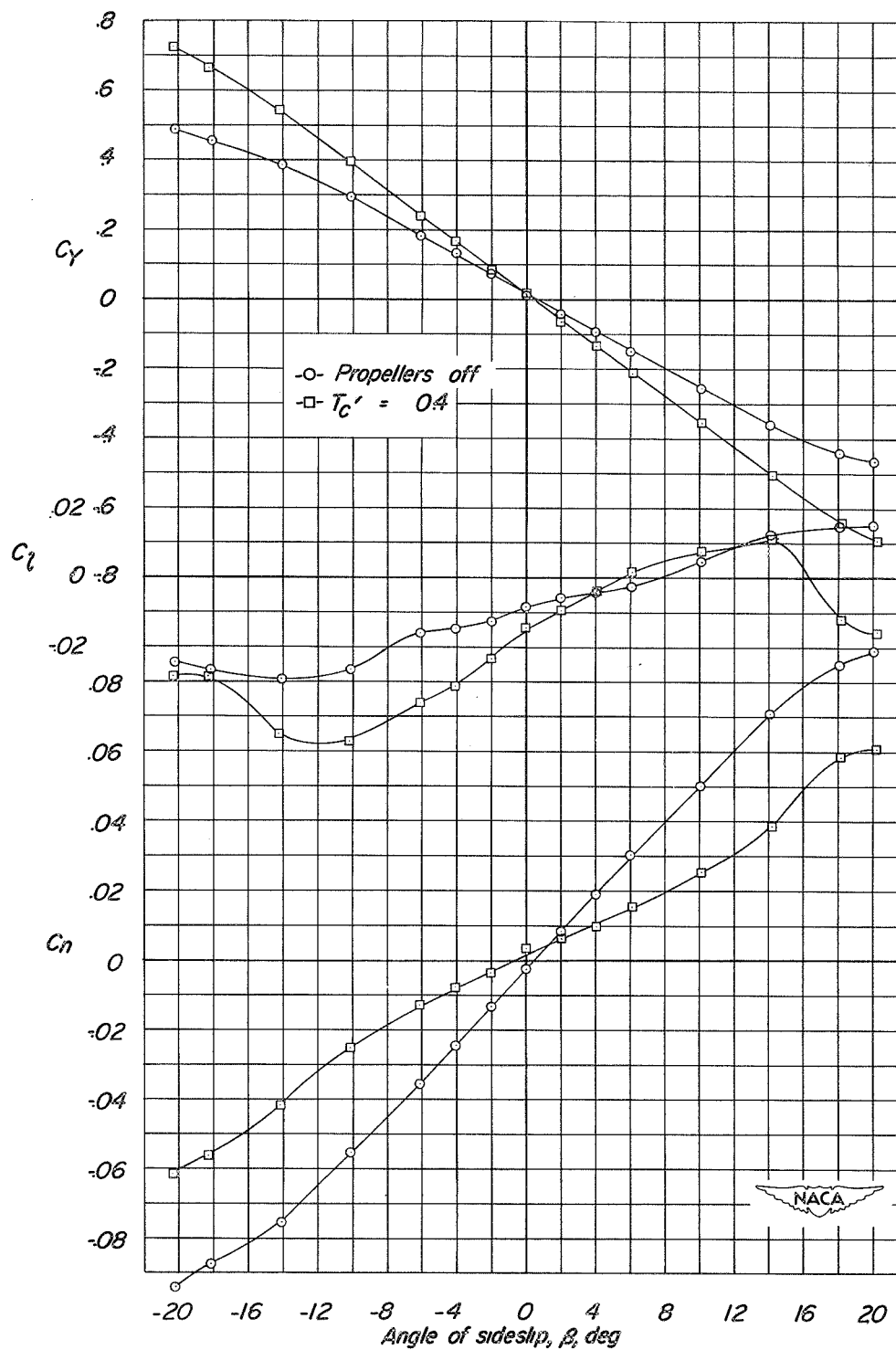
(a) Complete model. $\alpha = 2.1$.

Figure 13.- Effect of power on the variation of C_Y , C_l , and C_n with sideslip angle for various angles of attack. Complete model. $(\beta_0)_F = 25^\circ$.



(b) Complete model. $\alpha = 12.5$.

Figure 13.- Continued.



(c) Complete model. $\alpha = 20.7$.

Figure 13.- Concluded.

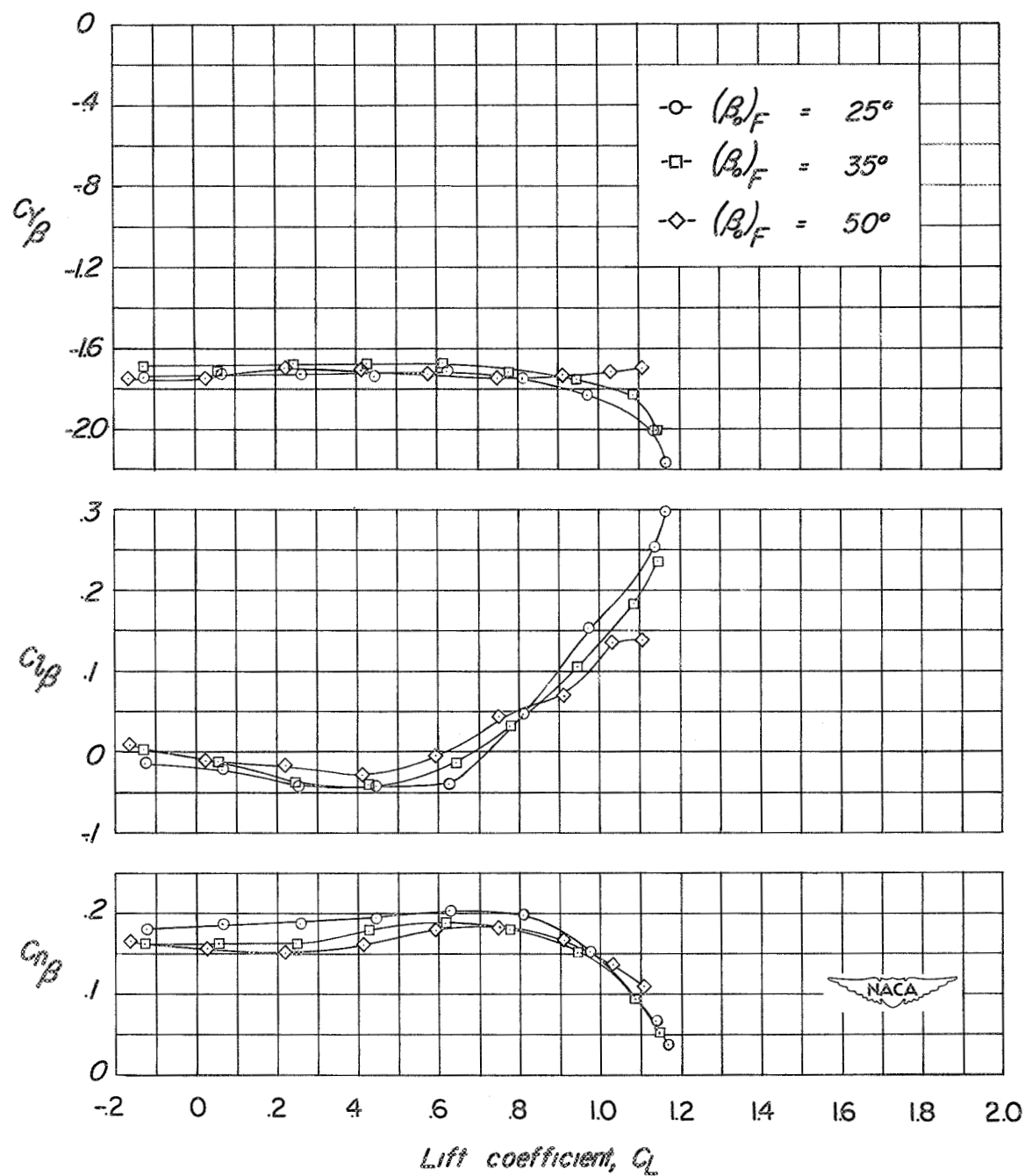
(a) $T_c' = 0$.

Figure 14.- Effect of blade angle on the static lateral stability parameters of a 1/9-scale powered model of the Convair XFY-1 vertically rising airplane operating at various thrust coefficients. Complete model.

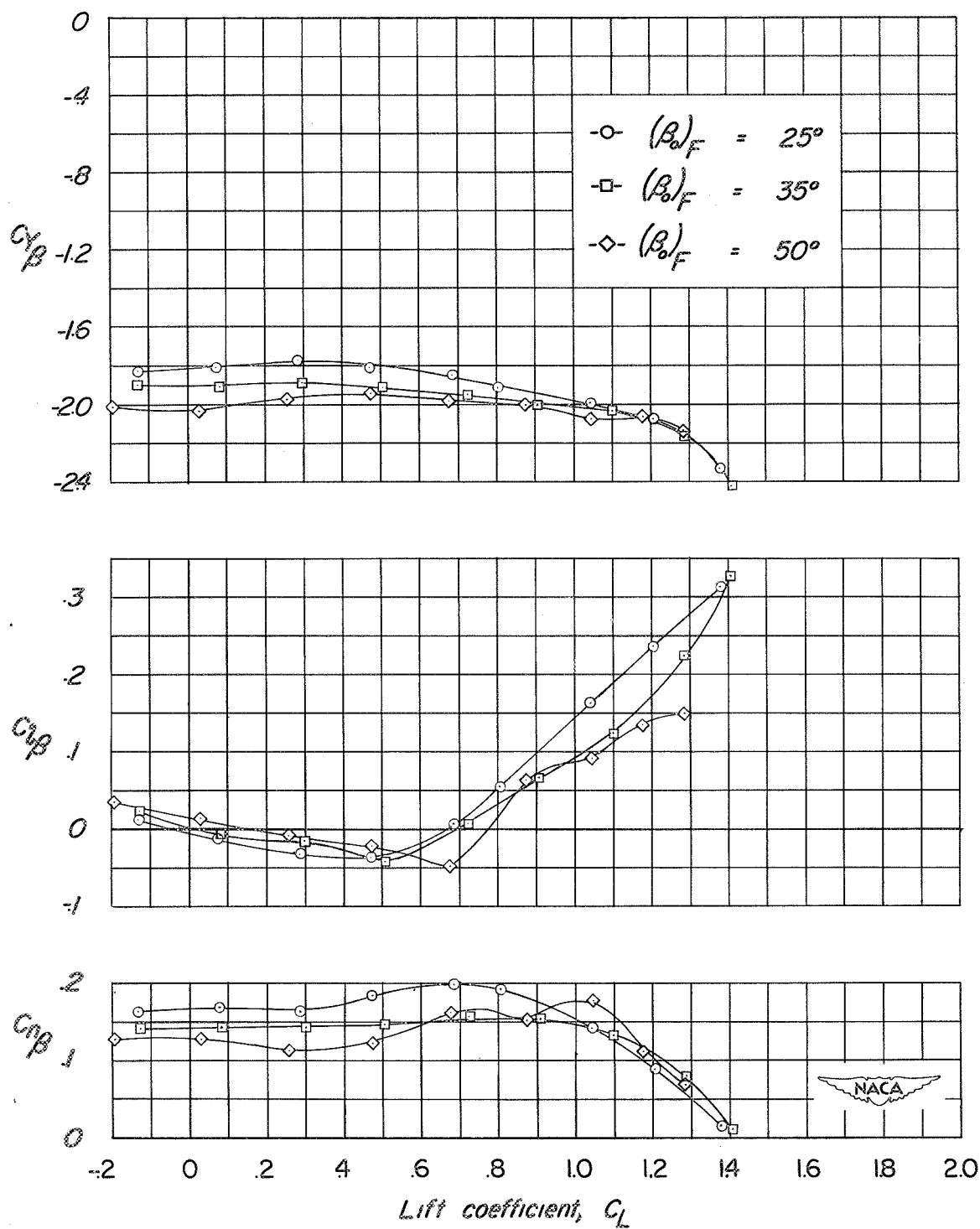
(b) $T_c' = 0.2$.

Figure 14. Continued.

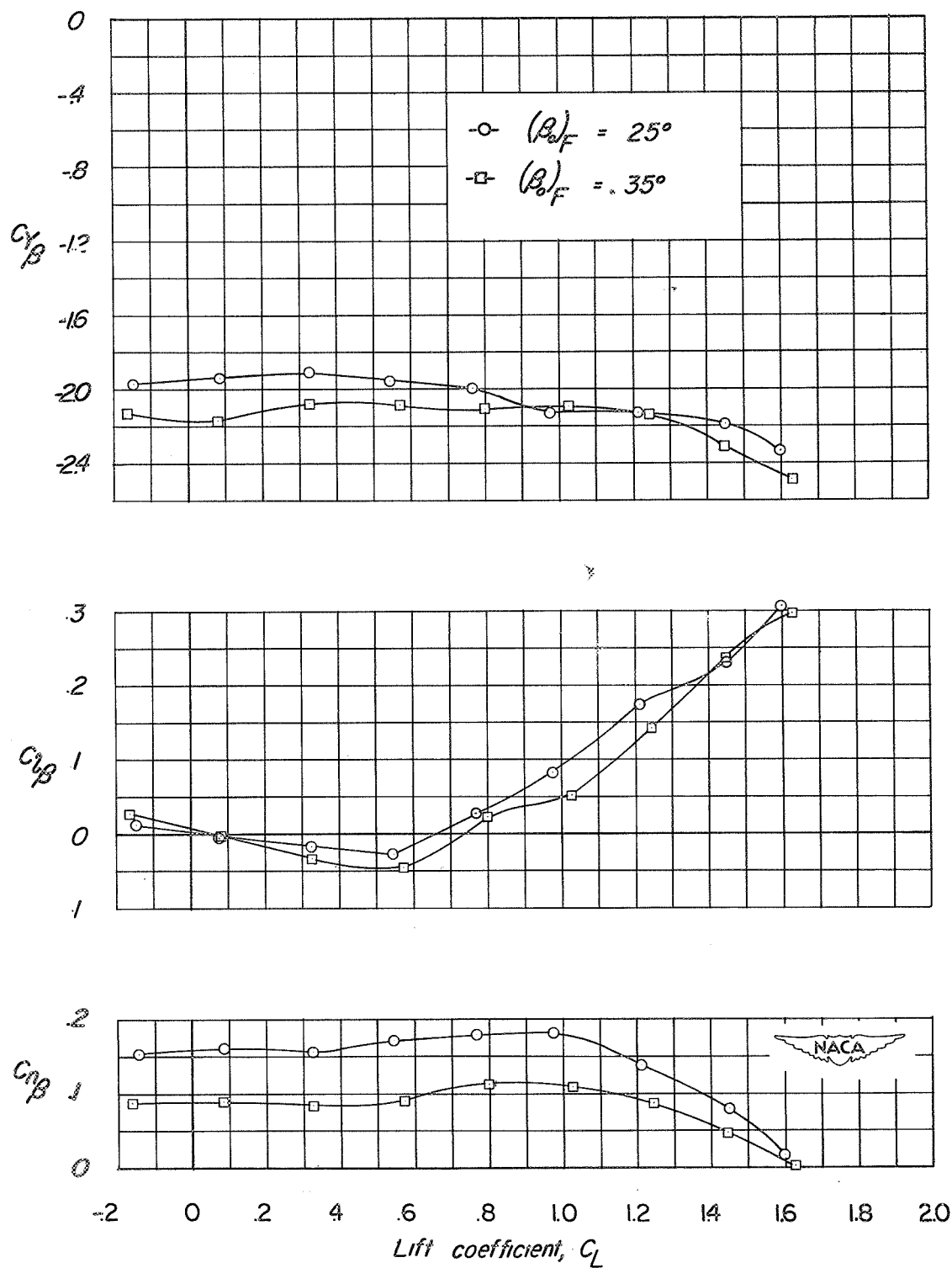
(c) $T_c' = 0.4$.

Figure 14.- Concluded.

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